

REMOTE PROCEDURE CALLING EXPRESSION GENERATION SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a remote procedure calling expression generation system for generating a procedure calling expression to execute a procedure remotely in a distributed computing environment where a resource object and a procedure for executing processing for a resource object are distributed, particularly relates to a remote procedure calling expression generation system for generating a procedure calling expression for requesting high functional service having high value added by combining plural remote procedure servers.

More specifically, the present invention relates to a remote procedure calling expression generation system for dynamically and efficiently generating a calling expression for calling complex service acquired by synthesizing plural remote procedures in a distributed computing environment where a resource object and the contents of processing respectively provided by each server vary dynamically.

The present invention targets a world wide web (WWW) system developed on the Internet which is a worldwide network as distributed computing system and can be applied in the case processing for a hyper text transfer protocol (HTTP) object which each HTTP server in WWW resource space manages, that is, a remote procedure is called using an HTTP request including a uniform resource locator (URL).

2. Description of the Related Art

Recently, technology related to network computing for mutually connecting computer systems via a network is actively developed. The object of the connection of computers via a network is made up of sharing mutual computer resources and the distribution and sharing of information.

For a communication medium for connecting computers, a local area network (LAN) installed in limited space such as inside an enterprise and an institute and a wide area network (WAN) in which LANs are connected via a dedicated line and others can be given. Recently, the Internet which is an enormous network covering the world is actively utilized. The Internet is a worldwide wide area network as the name shows and servers (mainly UNIX workstations) on the Internet are connected according to a transmission control protocol/internet protocol (TCP/IP).

Each resource object distributed on the Internet is specified by a reference (or a name) in a format of a URL. The URL means a character string for specifying the name and the location of a resource in resource space such as a network and is described in a format of a scheme name (a protocol name): //host name (domain name): port number/path name (fine name). URL is described in requests for comments (RFC) 1738 and 1808 for example. Also, a host name described above complies with a domain name system which is name service used in a network according to TCP/IP.

Various resource provision services are open on the Internet. WWW which is the typical example is a distributed information retrieval system for widely providing a resource object with hyperlink structure described in language in a markup format of hyper text markup language (HTML) on the Internet. A resource access is normally performed between a WWW server and a WWW client according to HTTP. HTML is described in RFC 1866 for example. Each resource object in an HTML format is also provided with a reference in a URL format described above. HTTP is described in RFCs 1945 and 2068 for example.

Currently, most computer systems on networks including the Internet are configured in distributed environment. This comes from the fact that in a centralized system, a load concentrates on one host, the host cannot meet increased clients and distributed environment that enables mutual equal connection is excellent in the

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remote procedure execution unit for executing calling service execute decision processing without defining a remote procedure for system service in an interface between application programs.

Also, ANSA information service framework of Architecture Projects Management Limited (England) is a distributed system based upon common object request broker architecture (CORBA) and WWW. In the distributed system, an Internet Inter-ORB Protocol (IIOP) for transferring a general Inter-ORB protocol using an Internet protocol (IP) is used and an access from WWW to a CORBA object is enabled by preparing a gateway for converting HTTP to IIOP and a gateway for converting IIOP to HTTP.

ANSA information service framework is described in "A Web of Distributed Object, The ANSA Project" (<http://www.ansa.co.uk/ANSA/ISF/wdistobj/Overview.html>) written by O. Rees, N. Edwards, M. Madsen, M. Beasley and A. McClenaghan and published in 1995 by Architecture Projects Management, Ltd. for example.

Also, DeleGate is a multiple use protocol relay system researched and developed by Yutaka Sato, an employee at Electrotechnical Laboratory. DeleGate provides various functions of path control, access control, protocol conversion, character code conversion, code conversion in Multipurpose Internet Mail Extensions (MIME), a data cache, a connection cache, relay for an existing application and mounting. However, DeleGate does not provide a system such as synthesizes a remote procedure call desired by a user by combining plural DeleGates in a network.

DeleGate is disclosed in "Multiple Use Protocol Relay System DeleGate" (Vol. 59, No. 6)(<ftp://etlport.etl.go.jp/pub/DeleGate/ETL-BULLETIN-95-06.ps.gz>) written by Yutaka Sato and published in 1995 by Electrotechnical Laboratory for example.

Recently, the provision of further high functional service having high value added by combining plural remote procedure servers has been requested.

(IETF), it is defined that URL should be used to call a CGI program.

Further, if a service in which plural remote procedure servers are combined is requested, URL generated by synthesizing URL character strings specifying each remote procedure can be utilized for a remote procedure calling expression.

A URL character string synthesized to call plural remote procedure servers is necessarily complex. If the contents of processing included in a remote procedure, that is, a remote procedure to be called is fixed, URL once generated can be continuously used. However, actually, in an open distributed network, the combination of remote procedure calls can vary from moment to moment. In the example shown in Fig. 3, there is a case where the contents P_B of processing executed by the remote procedure server B are to be changed from the merge of the objects O_{B1} and O_{B2} to the summary of the objects O_{B1} and O_{B2} . Or as the remote procedure server D in charge of a part of a series of processing is closed, there is also a case where the contents of processing executed by the remote procedure server C are required to be modified.

In such a case, every time the combination of remote procedures is varied, a synthetic URL expression for a remote procedure call first generated is required to be modified or changed. As the combination of called remote procedures becomes complex and comes to have multiple levels, work for modifying or changing a synthetic expression becomes more and more troublesome and difficult.

Also, all sites related to a remote procedure call do not belong to the same organization and it is impossible to completely grasp the change of the combination of remote procedure calls at one certain specific site. For example, in the example shown in Fig. 3, for a site in a route in which a final WWW page is passed to a client, in such a case, work for generating a synthetic URL expression for a remote procedure call is not only troublesome but almost impossible.

SUMMARY OF THE INVENTION

The invention is made to solve the technical problems described above and provides an excellent remote procedure calling expression generation system in which a procedure calling expression for executing a procedure remotely can be dynamically and efficiently generated in a distributed computing environment where a resource object and a procedure for processing for a resource object are distributed.

The invention further provides an excellent remote procedure calling expression generation system in which a procedure calling expression for enabling requesting high functional service having high value added by combining plural remote procedure servers can be dynamically and efficiently generated.

The invention further provides an excellent remote procedure calling expression generation system in which a procedure calling expression for calling complex service made up of synthesizing plural remote procedures can be dynamically and efficiently generated.

The invention further provides an excellent remote procedure calling expression generation system in which URL for requesting complex service made up of combining plural remote procedure servers can be dynamically and efficiently generated in WWW resource space where an HTTP object and processing for an HTTP object, that is, a procedure (method), are distributed.

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The invention is made to solve the problems described above, a first aspect is based upon a system for generating a remote procedure calling expression for requesting

service made up by combining plural procedures in resource space in which a resource object and a procedure for processing a resource object are distributed and relates to a remote procedure calling expression generation system characterized in that plural hyperobject sections are provided, each hyperobject section is provided with a procedure calling expression generation rule storage section for storing a procedure calling expression generation rule for generating a procedure calling expression, one or more attribute storage sections for storing an attribute value and a link storage section for storing one or more pieces of link information of the other hyperobject sections, and a procedure calling expression generation rule stored in the procedure calling expression generation rule storage section includes a character string according to a predetermined syntax rule for describing one or more generation rule elements made up of the reference to an attribute value and/or the reference to the result of the generation of a procedure calling expression in the linked hyperobject section.

The hyperobject section described above may also be further provided with a generation rule element extracting section for interpreting a procedure calling expression generation rule stored in the procedure calling expression generation rule storage section according to the predetermined syntax rule and extracting a generation rule element, a section for searching the attribute storage section if the extracted generation rule element is the reference to an attribute value and substituting the corresponding attribute value for the generation rule element and a section for issuing a request for generating a procedure calling expression to the linked hyperobject section if the extracted generation rule element is the reference to the result of the generation of a procedure calling expression in the linked hyperobject section and substituting the result of the generation of the procedure calling expression by the linked hyperobject section for the generation rule element. A procedure calling expression for requesting complex service made up of combining plural procedures can be dynamically and efficiently generated by

activating these sections in response to a request for generating a procedure calling expression.

The hyperobject section described above may also be an object-oriented program for generating a hypertext. The program can be described using Java programming language for example.

Also, a second aspect of the invention is based upon a remote procedure calling expression generation system for generating URL for requesting service made up by combining plural procedure servers in WWW resource space in which an HTTP object and a procedure for processing an HTTP object are distributed and relates to a remote procedure calling expression generation system characterized in that plural hyperobject sections are provided, each hyperobject section is provided with a URL generation rule storage section for storing a URL generation rule for generating URL as a procedure calling expression, one or more attribute storage sections for storing an attribute value and a link storage section for storing one or more pieces of link information of the other hyperobject sections, and a URL generation rule stored in the URL generation rule storage section includes a character string according to a predetermined syntax rule for describing one or more URL generation rule elements including the reference to an attribute value and/or the reference to the result of the generation of URL in the linked hyperobject section.

The hyperobject section described above may also be further provided with a URL generation rule element extracting section for interpreting a URL generation rule stored in the URL generation rule storage section according to the predetermined syntax rule and extracting a URL generation rule element, a section for searching the attribute storage section if the extracted URL generation rule element is the reference to an attribute value and substituting the corresponding attribute value for the URL generation rule element and a section for issuing a request for generating URL to the linked

hyperobject section if the extracted URL generation rule element is the reference to the result of the generation of URL in the linked hyperobject section and substituting the result of the generation of URL by the linked hyperobject section for the URL generation rule element. A procedure calling expression for requesting complex service made up by combining plural procedure servers in WWW resource space can be dynamically and efficiently generated by activating these sections in response to a request for generating URL.

Also, a third aspect of the invention is based upon a hyperobject for generating a remote procedure calling expression for requesting service made up by combining plural procedures in resource space in which a resource object and a procedure for processing a resource object are distributed and relates to a hyperobject characterized in that a procedure calling expression generation rule storage section for storing a procedure calling expression generation rule for generating a procedure calling expression, one or more attribute storage sections for storing an attribute value and a link storage section for storing one or more pieces of link information of the other hyperobjects are provided, wherein a procedure calling expression generation rule stored in the procedure calling expression generation rule storage section includes a character string according to a predetermined syntax rule for describing one or more generation rule elements including the reference to an attribute value and/or the reference to the result of the generation of a procedure calling expression in a linked hyperobject.

The hyperobject in the third aspect of the invention is an object-oriented program for generating a hypertext for example and can be described using Java programming language. The hyperobject can include processing including a step for interpreting a procedure calling expression generation rule stored in the procedure calling expression generation rule storage section according to the predetermined syntax rule and extracting a generation rule element, a step for searching the attribute storage

section if the extracted generation rule element is the reference to an attribute value and substituting the corresponding attribute value for the generation rule element and a step for issuing a request for generating a procedure calling expression to the linked hyperobject if the extracted generation rule element is the reference to the result of the generation of a procedure calling expression in the linked hyperobject and substituting the result of the generation of the procedure calling expression by the linked hyperobject for the generation rule element. A procedure calling expression for requesting complex service made up by combining plural procedures can be dynamically and efficiently generated by activating such processing in response to a request for generating a procedure calling expression.

Also, a fourth aspect of the invention is based upon a hyperobject for generating URL for requesting service made up by combining plural procedure servers in WWW resource space in which an HTTP object and a procedure for processing an HTTP object are distributed and relates to a hyperobject characterized in that a URL generation rule storage section for storing a URL generation rule for generating URL as a procedure calling expression, one or more attribute storage sections for storing an attribute value and a link storage section for storing one or more pieces of link information of the other hyperobjects are provided, wherein a URL generation rule stored in the URL generation rule storage section includes a character string according to a predetermined syntax rule for describing one or more URL generation rule elements including the reference to an attribute value and/or the reference to the result of the generation of URL in a linked hyperobject.

The hyperobject related to the fourth aspect of the invention is an object-oriented program for generating a hypertext for example, is described using Java programming language and can be activated on a WWW browser. The hyperobject can include processing having a step for interpreting a URL generation rule stored in the

URL generation rule storage section according to the predetermined syntax rule and extracting a URL generation rule element, a step for searching the attribute storage section if the extracted URL generation rule element is the reference to an attribute value and substituting the corresponding attribute value for the URL generation rule element and a step for issuing a request for generating URL to a linked hyperobject if the extracted URL generation rule element is the reference to the result of the generation of URL in the linked hyperobject and substituting the result of the generation of URL by the linked hyperobject for the URL generation rule element. A procedure calling expression in a URL format for requesting complex service made up by combining plural procedure servers in WWW resource space can be dynamically and efficiently generated by activating such processing in response to a request for generating URL.

Other characteristics and advantages of the invention will become clear by the more detailed description of an embodiment described later of the invention based upon the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

A preferred embodiment of the invention will be described in detail based on the followings, wherein:

Fig. 1 schematically shows a remote procedure calling system in an embodiment of the invention;

Fig. 2 is another view schematically showing the remote procedure calling system in the embodiment of the invention; and

Fig. 3 schematically shows circumstances in which a complex resource object is provided by synthesizing plural remote procedures.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings, an embodiment of the invention will be described in detail below.

Generally, a remote procedure calling system including one or more hyperobjects. Each hyperobject shall be located in a distributed computing environment. That is, each hyperobject may also be located on one server connected via a distributed network (not shown) and may also be distributed to different servers.

A case where a remote procedure is implemented by P hyperobjects will be considered below. Fig. 1 schematically shows the remote procedure calling system.

The URL generation rule storage stores a rule for generating URL in the format of a character string. URL described above is not only an object identifier for uniquely defining a resource object in a distributed network but a remote procedure calling expression. Processing which a hyperobject includes can generate URL according to an algorithm which a character string stored in the URL generation rule storage defines. However, a procedure for generating URL will be described in detail later.

convenience of explanation, however, generally, an attribute value may be described in an arbitrary data format.

The link storage stores a link with another hyperobject or with its own hyperobject. In this embodiment, both URL in WWW and an internal reference in program execution environment can be treated as a link. Generally, a link has only to be a reference by which an object can be identified in distributed computing environment. A linked hyperobject shall be treated as a child of a hyperobject that links below.

Next, a URL generation rule treated in this embodiment will be described. The URL generation rule is a character string defined according to the following syntax. [Expression 1]

$G \rightarrow V \mid C \mid A \mid \text{Alpha}$

$G \rightarrow GG$

$V \rightarrow \{\text{Alpha}\}$

$C \rightarrow \{\text{children}\}$

$A \rightarrow \&G$

$\text{Alpha} \rightarrow \text{character string made up of characters except } \{ \}$

G described above denotes a set of URL generation rules, V described above denotes a notation for referring to an attribute value, C described above denotes a notation for referring to the result of the generation of URL in a hyperobject equivalent to a child, A described above denotes a notation for an argument in URL and Alpha described above denotes one or more arbitrary character strings made up of characters except { }.

In the syntax used in this embodiment of URL generation rules, a character such as " {", "}" and "&" is used for a terminal symbol (or a delimiter). However, a character or a character string except the characters described above can be used for a

terminal symbol in a range compatible with the syntax. Also, a terminal symbol {children} for referring to the result of the generation of URL according to a URL generation rule of a hyperobject equivalent to a child may also be replaced by another character string in a range compatible with the syntax.

For an example of a URL generation rule, the following character string which the URL generation rule 1 of a hyperobject #1 has will be described below.

[Expression 2]

http://foo. co. jp/{name}/{date}

The URL generation rule 1 includes two notations {name} and {date} for referring to an attribute. In this case, URL generation algorithm refers to the attribute storage and substitutes the attribute value of an attribute name "name" for {name} in a character string.

Next, a procedure for generating URL will be described below using a remote procedure call made up of four hyperobjects shown in Fig. 2 as an example.

A hyperobject #1 shall store the following character string as the URL generation rule 1.

[Expression 3]

http://foo. co. jp/bin/procedure? {children}

&name = {name} & info = {description} & option = 1

Also, an attribute storage 11 shall store "object 1" as an attribute value of the attribute name "name" and an attribute storage 12 shall store "root node" as an attribute value of an attribute name "description". Also, a link storage 11 shall store reference to a hyperobject #2 and a link storage 21 shall store reference to a hyperobject #4.

Also, the hyperobject #2 shall store the following character string as a URL generation rule 2.

[Expression 4]

`http://bar.co.jp/bin/open?owner = {user}`

Also, an attribute storage 12 of the hyperobject #2 shall store "horikiri" as an attribute value of an attribute name "user" and a link storage 12 shall store reference to a hyperobject #3.

[Expression 5]

Algorithm 1

generating URL is issued to each hyperobject equivalent to a child to be referred.

If a character string acquired from each of the child objects is a notation for an argument in URL, the passed character string is concatenated to the URL character string as it is. If not, a character string given from the child object is encoded and is concatenated to "&arg=".

(5) If the fetched URL generation rule element is not a notation for reference, the corresponding character string is output as it is.

(6) If a notation for referring to the result of the generation of URL in a hyperobject equivalent to a child is not included in the fetched URL generation rule element, a request for generating URL is issued to each of hyperobjects equivalent to a child.

If a character string acquired as the result of the request for generating URL is a notation for an argument in URL, the character string is concatenated to a character string showing the result as it is and if not, a character string given from a hyperobject equivalent to a child is encoded and is concatenated to "&arg=".

Next, a processing procedure executed when a request for generating URL is issued to the hyperobject #1 will be described in detail using a case shown in Fig. 2 as an example.

The hyperobject #1 divides the URL character string shown in the expression 3 according to a syntax rule in response to the receiving of the request for generating URL and acquires the following each character string (that is, a URL generation rule element).

[Expression 6]

- "http://foo. co. jp/bin/procedure?"
- "{children}"
- "&name="

- "{name}"
- "&info="
- "{description}"
- "&option=1"

As a URL generation rule element "http://foo. co. jp/bin/procedure?" is not a notation for reference, it is output as it is.

Also, as a URL generation rule element "{children}" is a notation for reference to a child object, a request for generating URL is reflexively issued to each of the hyperobjects #2 and #4 respectively referred as a child.

The hyperobject #2 executes the algorithm 1 as described above when it receives the request for generating URL.

That is, the hyperobject #2 first divides the URL generation rule shown in the expression 4 according to a syntax rule and acquires the following each character string (that is, a URL generation rule element).

[Expression 7]

- "http://bar. co. jp/bin/open?owner="
- "{user}"

As a URL generation rule element "http://bar. co. jp/bin/open?owner=" is not a notation for reference, it is output as it is.

Also, as a URL generation rule element, "{user}" is a notation for referring to an attribute value, an attribute is retrieved using the corresponding to the corresponding attribute name in the attribute storage. That is, the corresponding attribute is retrieved using the attribute name of the URL generation rule element in the attribute storage. In an example shown in Fig. 2, as "horikiri" exists as the corresponding attribute, a character string acquired by encoding an attribute value "horikiri" is substituted for the URL generation rule element.

Also, the URL generation rule 2 which the hyperobject #2 has does not include a notation for referring to the result of the generation of URL in a hyperobject equivalent to a child as a URL generation rule (refer to the expression 4). Therefore, a request for generating URL is reflexively issued to each of hyperobjects equivalent to a child (the hyperobject #3 in the example shown in Fig. 2).

When the hyperobject #3 receives the request for generating URL, it executes the algorithm 1 as described above.

That is, the hyperobject #3 first divides the URL generation rule shown in the expression 5 according to a syntax rule and acquires the following each character string (that is, a URL generation rule element).

[Expression 8]

- "http://fujixerox. co. jp/"

As a URL generation rule element "http://fujixerox. co. jp/" is not a notation for reference, it is output as it is. As a child object is not referred though the URL generation rule 3 which the hyperobject #3 has does not include a notation for referring to the result of the generation of URL in the child object as a URL generation rule, a reflexive request for generating URL is not made.

The hyperobject #2 receives "http://fujixerox. co. jp/" from the hyperobject #3 as the result of the generation of URL. As the character string does not correspond to a notation for an argument in URL, "&arg=(http://fujixerox. co. jp)" is output. However, an encoded character string shall be shown in a parenthesis.

As a result, the hyperobject #2 outputs the following character string to the hyperobject #1 which requests the generation of URL.

[Expression 9]

"http://bar. co. jp/bun/open?owner=horikiri
&arg= (http://www. fujixerox. co. jp)"

When the hyperobject #1 receives the character string described above from the hyperobject #2 as the result of the generation of URL, the following character string is output because the character string described above is not a notation for an argument in URL.

[Expression 10]

```
"&arg= (http://bar. co. jp/bun/open?owner= horikiri
    &arg= (http://www. fujixerox. co. jp))"
```

In the meantime, when the hyperobject #4 receives a request for generating URL, it also executes the algorithm 1 as described above.

That is, the hyperobject #4 first divides the URL generation rule, "time={date}" according to a syntax rule and acquires the following each character string (that is, a URL generation rule element).

[Expression 11]

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- "&time="
- "{date}"
```

The hyperobject #4 outputs "&time=". Next, as "{date}" is a notation for referring to an attribute, a character string acquired by encoding "1999/6/18" which is an attribute value is output. Therefore, the following character string is returned to the hyperobject #1 which requests the generation of URL.

[Expression 12]

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"&time= {1999/6/18}"
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The hyperobject #1 outputs the received character string as it is because the character string is a notation for an argument in URL.

Next, the hyperobject #1 processes the residual URL generation rule element. That is, it outputs the next element, "&name=".

As the next URL generation rule element "{name}" is a notation for referring

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Next, the hyperobject #1 outputs the next URL generation rule element "&info=".

As the next URL generation rule element "{description}" is a notation for referring to an attribute, the attribute is retrieved in the attribute storage, and a character string "{root node}" acquired by encoding the corresponding attribute value "root node" is output.

Next, the hyperobject #1 outputs the next URL generation rule element "&option=1" as it is.

As a result, the hyperobject #1 outputs the following URL synthetic expression.

[Expression 13]

http://foo. co. jp/bin/procedure?

&arg= (http://bar. co. jp/bun/open?owner=horikiri

&arg=(http://www.fujixerox.co.jp))

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&time= (1999/6/18) &name=object1&info= (root node) &option=1")
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The URL character string described above is equivalent to a procedure calling expression for requesting service made up of the combination of plural remote procedure servers shown in Fig. 2. A user who requests the hyperobject #1 to generate URL can acquire the URL synthetic expression and can call complex service using the expression.

Referring to the specific embodiment, the invention has been described in detail above. However, it is obvious that the manufacturer can modify and substitute the embodiment in a range which does not deviate from the outline of the invention. That is, the invention has been disclosed as an embodiment and should not be limitedly interpreted. To judge the outline of the invention, the following claims should be

considered.

As described in detail above, according to the invention, it is possible to provide the excellent remote procedure calling expression generation system to dynamically and efficiently generate the procedure calling expression by which a procedure can be remotely called in distributed computing environment in which a resource object and a procedure for processing a resource object are distributed.

Also, according to the invention, it is possible to provide the excellent remote procedure calling expression generation system in which the procedure calling expression for requesting high functional service having high value added made up by combining plural remote procedure servers can be dynamically and efficiently generated.

Also, according to the invention, it is possible to provide the excellent remote procedure calling expression generation system in which the calling expression for calling complex service made up by synthesizing plural remote procedures can be dynamically and efficiently generated.

Also, according to the invention, it is possible to provide the excellent remote procedure calling expression generation system in which the procedure calling expression in a URL format for calling complex service made up by combining plural remote procedure servers can be dynamically and efficiently generated in WWW resource space where an HTTP object and processing for an HTTP object, that is, the procedure (method) are distributed.